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(54) Web drying machine

(57) Web drying apparatus having a permeable dryer fabric (12) to hold the web (11) being dried against the peripheries of a plurality of drying cylinders (10), the apparatus being provided with at least one plenum (1) which extends laterally between adjacent drying cylinders (10), the plenum (1) having an outlet (4) directed towards the permeable fabric (12) where the fabric leaves one cylinder and a foil (6) which extends from the plenum (1) to the permeable fabric (12) at the downstream side of the outlet (4) with respect to the direction of fabric movement to direct web drying medium leaving said outlet through said permeable fabric and against said web, the apparatus being characterised in that said plenum further comprises a second foil (7) which extends from the plenum to the permeable fabric (12) at the upstream side of the outlet (4) with respect to the direction of fabric movement to redirect at least some of the boundary layer of air away from said fabric (12) before said fabric passes said outlet (4).

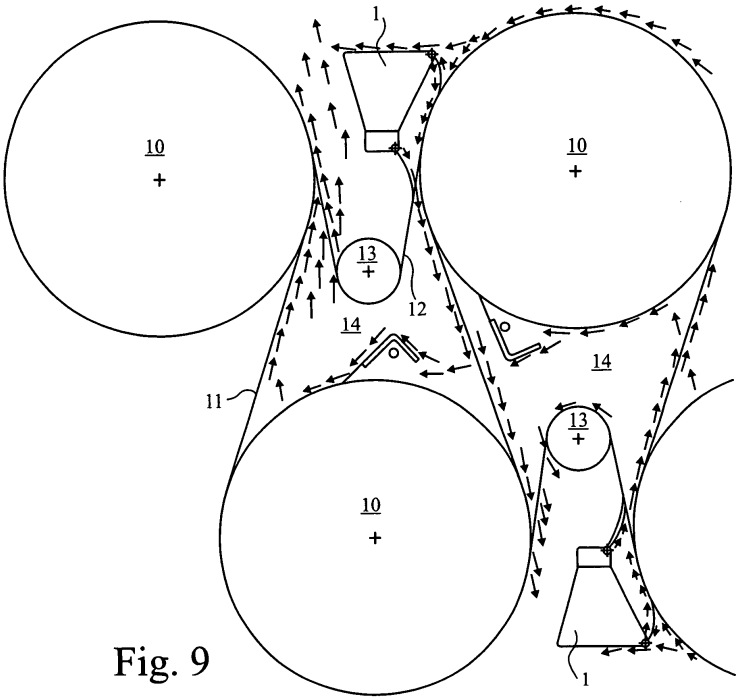

Fig. 9

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Description

[0001] This invention relates to the field of web drying apparatus for the paper-making industry, wherein it is desired to introduce heated air to the surface of a paper or board web, for example, to assist in the drying rate of the web.

BACKGROUND

[0002] The steam-heated cast iron drying cylinder or can was invented and patented by T.B. Crompton, a British papermaker living in Bury, Lancashire in 1821, just 16 years after the Fourdrinier brothers first produced continuous paper at Frogmore Mill, in Hemel Hempstead, Hertfordshire in 1805.

[0003] Since then the cast iron cylinders, with very little change in principle have served the paper industry very well and will continue to do so for a long time to come.

[0004] No other mechanism is able to support and constrain the sheet better while applying copious amounts of heat to dry it without the need to raise the cylinder surface temperature above about 150°C and at speeds in excess of 1500 m/min.

[0005] To get the best from the drying cylinders it is important to understand the drying mechanism taking place on the machine.

[0006] At first, Crompton simply laid the sheet against the cylinders; pulled tight enough it will dry very well, but to get the desired stiffness, it is better to have some constraint. The drying was fairly good because the evaporation took place on the open surface away from the cylinder surface applying the heat and the speeds were modest. Many mills still run like this today.

[0007] Felt manufacturers developed cotton felts to run against the cylinder, which had the effect of constraining the sheet, absorbing the moisture and improving stiffness. The cotton felts had to be dried so felt dryers were installed to do this but it soon became obvious that on wider, faster machines, it was necessary to push the moisture out of the drying section by using air jets and other devices. Where felts are employed, evaporation takes place in the pockets between the cylinders and if the air used to purge the pockets is hot enough it absorbs the moisture and the hot moist air can then be extracted from the building. Devices of this type were referred to as Grewin Systems.

[0008] The felt makers later replaced the felts with fabrics. The fabrics were much stronger than the felts and could be pulled tighter and thereby improve heat transfer. The fabrics were also highly porous and they did not rot.

[0009] With the new fabrics and better ventilation system the old cylinders could be made to perform very well.

[0010] However, a distinction needs to be made between drying board and drying paper. The thickness of board has a very substantial effect on the way the drying process takes place. To fully understand it, one has to think about the process in 3D, not in 2D. The drying process actually starts at the presses, which consolidate the sheet and give it an undesirable 'Z' direction profile. The press felts squeeze the water from the top and bottom of the sheet causing the surfaces to dry but not the middle. The water in the middle will not move under the influence of the felts because there is nothing to encourage this. Machines can be said to be running 50% solids from the presses, but what this means is that, although the average is 50% through the sheet, the surface solids are nearer 70% while the middle of the sheet is still the same as it came into the press section, about 30% solids. The sheet enters the cylinder section with this poor profile and that profile remains until the size press or calenders.

[0011] The only stimulus to make the moisture move is heat and this needs to be delivered into the sheet as soon as possible after the presses. Heat in the middle of the sheet raises the vapour pressure and provides the driving force to move the moisture to the surface, where it comes into contact with the cylinder surface, from which it takes the latent heat of vaporisation to cause evaporation. If the water is insufficiently hot, the moisture remains in the middle of the sheet while the surface fibres dry and shrink. The shrinking process not only shortens the fibres on the surface but it tightens and reduces the surface porosity making evaporation of the middle moisture more difficult, once it does get the surface.

[0012] The drying process is merely a matter of providing the moisture with enough energy to encourage it to move away from the centre of the sheet to the surface and so to evaporate. It does not have to boil and the movement of the water takes place due to vapour pressure differential.

[0013] The drying process for board comprises three distinct phases. First the heating phase, where the sheet is brought up to the constant rate temperature, usually in the first 10% of the drying capacity. Secondly, the constant rate phase where the sheet temperature remains fairly constant as does rate of evaporation. Thirdly, as the evaporation rate slows because the moisture becomes more difficult to move from the centre of the sheet to the surface, the falling rate phase is entered and the sheet temperature rises.

[0014] During the heating phase the objective is to get the water temperature up to at least 72°C as quickly as possible on entering the cylinder section. This helps cylinder performance and helps prevent picking. This needs to be achieved in the first 10% of cylinders.

[0015] The constant rate phase is the part of the drying process where the input from the cylinders more or less balances the latent heat load to provide evaporation. This phase normally lasts through about 65% of the total dryers. As the sheet surface starts to dry, where the average solids content is about 70%, so the surface temperature starts to rise because the surface fibres are virtually dry.

[0016] The falling rate phase starts as the surface temperature rises and the evaporation rate slows. The falling rate and associated temperature rise is brought about by the fact that the surface temperature is higher than that

of the moisture in the middle, which will not move until it has become hot enough, and so the rate of moisture movement slows down.

The Boundary Layer

[0017] The boundary layer is a layer of air which forms on the surface of a moving body to lubricate the interface between the sea of air in which we live and the moving body. It is what keeps an aeroplane in the air and a racing car on the ground. It is a bone of contention to the papermaker, but it is what carries the water away from the sheet, or does not, as the case may be. Its humidity can be measured and can be seen with the aid of smoke.

[0018] On a paper machine, the movement of the sheet through the machine, over all rolls and cylinders generates a boundary layer. The boundary layer on the wet end gives no problem but in the drying section, if not handled correctly, the boundary layer causes quality and drying performance issues.

[0019] Drying cylinders or cans carrying the sheet, with or without felts cause the formation of the boundary layer. It usually has a thickness of between 6 and 12 mm, depending upon speed and the uninterrupted length of the sheet run, the position of lead rolls and the like.

[0020] The boundary layer has a particular effect on drying cylinder performance and fabrics, because when it becomes saturated it inhibits evaporation. The boundary layer forms an attachment to the cylinder, sheet and fabric and where the fabric moves away from the sheet as the sheet enters the top pocket, a low pressure or depression is formed and the boundary layer passes through the mesh of the fabric and follows the sheet. It is a mild pumping action. As the boundary layer in most cases is virtually saturated in the hood, on top cylinders it becomes totally saturated as it moves through the pocket, as the moisture evaporates. Where the layer forms in the basement, it is cold and, as cold air carries relatively little moisture, it again rapidly becomes saturated with the same results, but the same pumping action exists. Where there are no felts, the boundary layer still forms and simply follows the sheet into the pockets, causing the same problems.

[0021] Warm air does carry more moisture than cold air and the hotter the air the more moisture it will carry, but when the air or mixture temperature is increased, so is the molecular activity, thereby increasing the vapour pressure and making it more difficult for the moisture to leave the sheet. The result is that the sheet has to run at an increased temperature to dry, so the temperature difference between the sheet and the cylinder surface is reduced, as is the heat transfer.

[0022] In all drying sections using fabrics, the bulk of the drying takes place in the draws or pockets, not while the sheet is held against the cylinder surface. It is normal in ideal conditions for the sheet to lose temperature as the sheet travels through the pocket, indicating that full evaporation is taking place. However, due to the stifling effect of the saturated boundary layer, we frequently find there is a temperature rise of 15°C through the pocket, which reduces evaporation capacity and heat transfer from the cylinders.

[0023] An improved web drying apparatus is disclosed in GB2153508 (Spooner Industries Limited) in which a multi-cylinder drying machine is fitted with ventilation boxes having nozzles for directing drying medium through a porous fabric and over the web being dried. A flexible curved plate extends from the downstream edge of the nozzle to the fabric. However this apparatus does not work so effectively at relatively low speeds of travel of the web, for example when the web is board which travels relatively slowly but has a relatively large quantity of moisture therein.

[0024] It is therefore an object of the present invention to provide web drying apparatus which seeks to alleviate the above-described problems.

SUMMARY OF THE INVENTION

[0025] According to a first aspect of the invention there is provided web drying apparatus having a permeable dryer fabric to hold the web being dried against the peripheries of a plurality of drying cylinders, the apparatus being provided with at least one plenum which extends laterally between adjacent drying cylinders, the plenum having an outlet directed towards the permeable fabric where the fabric leaves one cylinder and a foil which extends from the plenum to the permeable fabric at the downstream side of the outlet with respect to the direction of fabric movement to direct web drying medium leaving said outlet through said permeable fabric and against said web, the apparatus being characterised in that said plenum further comprises a second foil which extends from the plenum to the permeable fabric at the upstream side of the outlet with respect to the direction of fabric movement to redirect at least some of the boundary layer of air away from said fabric before said fabric passes said outlet.

[0026] Preferably, either br both of said foils are flexible so as to be deflectable so that a paper wad or the like can pass.

[0027] Ideally, said web drying medium is heated air.

[0028] In a preferred form, either foil is removable and replaceable from said plenum, ideally by sliding said foil laterally from a groove in the exterior surface of said plenum.

[0029] Preferably, either foil is made from a laminate comprising epoxy resin and glass fibre. Alternatively, either foil is made from metal, preferably aluminium or spring steel. In one embodiment, either foil comprises a brush.

[0030] Preferably, said second foil extends from said plenum to said fabric substantially in the direction of fabric movement. Alternatively, said second foil extends from said plenum to said fabric substantially contrary to the direction of fabric movement.

[0031] In one embodiment, said second foil is pivotally attached to said plenum.

[0032] In a preferred form, either foil is bent to a predetermined shape prior to attaching said foil to said plenum.

[0033] Preferably, said plenum comprises a plurality of plenum sections attached together to give a plenum of the desired length, the plenum sections being formed from flat-pack sections which can be assembled on site.

[0034] Preferably, said plenum includes a plurality of outlets arranged along the length of the plenum.

[0035] Advantageously, said plenum includes flow rate control means to enable the flow rate of drying medium through each outlet to vary along the length of the plenum.

[0036] In a preferred form, said plenum has an endstop in the form of an extension provided with a curved wall against which either foil may be deflected to substantially prevent over-bending of the foil.

[0037] Preferably, said plenum is spaced by at least 100mm from the adjacent drying cylinder.

[0038] Preferably, said plenum is generally triangular in cross-section.

[0039] In a preferred embodiment, the free edge of either foil is curved back away from said fabric.

[0040] According to a second aspect of the invention there is provided a plenum for use in web drying apparatus as described in any of the preceding paragraphs, the plenum having an outlet which, in use, is directed towards the permeable fabric where the fabric leaves one cylinder a foil which, in use, extends from the plenum to the permeable fabric at the downstream side of the outlet with respect to the direction of fabric movement to direct web drying medium leaving said outlet through said permeable fabric and against said web, and a second foil which, in use, extends from the plenum to the permeable fabric at the upstream side of the outlet with respect to the direction of fabric movement to redirect at least some of the boundary layer of air away from said fabric before said fabric passes said outlet.

[0041] The apparatus of the present invention controls or manages the boundary layer to provide an improved drying solution for paper manufacturing to enhance the quality of the end product and to save energy in the production thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0042] Preferred embodiments of the present invention will now be more particular described, by way of example only, with reference to the accompanying drawings, wherein:

Figure 1 is a perspective view of a plenum for use in web drying apparatus according to the invention;

Figure 2 is a perspective view of the plenum of Figure 1, partially cut away to show internal constructional features;

Figures 3-8 are, respectively, top, front, bottom, back, operating side and drive side views of the plenum of Figure 1;

Figure 9 is a schematic view of web drying apparatus according to the invention including the plenum of Figure 1;

Figure 10 shows part of the apparatus of Figure 9, drawn to a larger scale, showing detail of the plenum; and

Figure 11 shows part of the apparatus of Figure 9, drawn to a larger scale, showing detail of an alternative embodiment of the plenum.

DETAILED DESCRIPTION

[0043] Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and "comprises", means "including but not limited to", and is not intended to (and does not) exclude other components, integers or steps.

[0044] Throughout the description and claims of this specification, the singular encompasses the plural unless the context otherwise requires. In particular, where the indefinite article is used, the specification is to be understood as contemplating plurality as well as singularity, unless the context requires otherwise.

[0045] Features, integers, characteristics, or groups thereof described in conjunction with a particular aspect, embodiment or example of the invention are to be understood to be applicable to any other aspect, embodiment or example described herein unless incompatible therewith.

[0046] The terms "leading edge", "trailing edge", "upstream" and "downstream" are defined relative to the direction of travel of the web being dried by the drying apparatus of the present invention.

[0047] Figures 1 and 2 show a plenum for use in the web drying apparatus of the present invention. The term "plenum" is not intended to be limiting and covers any suitable chamber for the distribution of drying medium (heated air, in the examples described below). The term "plenum" is used interchangeably to mean individual plenum sections and also a plurality of individual plenum sections joined together, the meaning being apparent by the context.

[0048] Figure 1 shows three individual plenum sections 1A, 1B, 1C joined together to form a plenum 1 of approximately 3 metres in length. The plenum is manufactured from AISI 304 stainless steel in pre-formed sections 1 metre in length. Any number of individual plenum sections can be riveted or otherwise attached together to form a plenum of an appropriate length to suit the in-

dividual machine. This allows the plenums to be conveniently shipped in a 'flat-pack' format and assembled on site.

[0049] The pre-formed plenum sections are cut out on laser profiling machines and formed using CNC bending equipment. This means that the plenum sections can be produced with precisely defined dimensions so that the individual sections can be readily riveted together (made possible by the alignment of accurately placed holes 2 and formers 3) so that the finished plenum has an air tight structure.

[0050] The plenum 1 is provided with a plurality of outlet holes 4, spaced along its length near the leading edge thereof and, at the trailing edge, an air inlet vent 5.

[0051] The plenum is fitted with two foils along the length thereof, a leading edge foil 6 and a trailing edge foil 7; each being manufactured from an epoxy bound laminated glass fibre. Other materials will be envisaged, so long as they are flexible and heat resistant to preferably at least 250°C. The term "foil" does not imply that said foil is made from metal; the term is used generically to describe the structure used to control the flow of the boundary layer, as will be described in more detail below. In one embodiment, the foil can be in the form of a brush rather than a laminate or sheet.

[0052] The foils 6, 7 are flexible enough to allow 100 mm wads to pass them (in the event of a breakage of the eb), whilst always maintaining their spring characteristics even when running at 250°C. The foils 6, 7 are slideably mounted on brackets extending along the length of the plenum 1 and are removable and replaceable. The angle of alignment of the foils 6, 7 within the brackets is adjustable.

[0053] Turning now to Figure 9, part of a web-drying machine with plenums in place is illustrated. The web drying apparatus comprises heated drying cylinders 10, over which the paper or board web 11 passes in serpentine fashion i.e. over the top cylinders and under the bottom cylinders. The web 11 is overlaid by a permeable dryer fabric 12, through which drying medium (e.g. heated air) is introduced via the plenums 1, the fabric 12 being held closely against the cylinders 10 by hitch rolls 13. The plenums 1 extend the full length of the cylinders 10.

[0054] The arrows in Figures 9-11 indicate airflow but also generally indicate the direction of travel of the web 11 and fabric 12.

[0055] Plenums 1 are installed in the drying apparatus adjacent drying cylinders 10, above or below the pockets (depending on whether the cylinders are upper or lower cylinders).

[0056] Pockets 14 are shown in Figure 9 and are the spaces between neighbouring drying cylinders 10, in which the hitch rolls 13 are located.

[0057] Figure 10 shows in more detail the interaction between plenum 1 and the boundary layer of air. The incoming boundary layer B_{old} has already performed a drying function as it approaches plenum 1 and is therefore saturated and less effective. As the boundary layer B_{old} arrives at plenum 1, it is diverted by trailing foil 7 over the top of the plenum 1 and away from the drying cylinder 10. In other words, the boundary layer B_{old} is stripped away from the drying cylinder 10.

[0058] The outlets 4 in the plenum 1 supply fresh low relative humidity air at about 85°C which is directed through the permeable fabric 12 towards the surface of the drying cylinder 10 to form a new boundary layer B_{new}. B_{new} passes through the fabric 12 and, where the web 11 and fabric 12 diverge, the web surface boundary layer is scoured in a turbulent manner which promotes rapid evaporation of the moisture being driven to the surface of the web 11 by the effect of the drying cylinder. This ensures that the moisture evaporates and there is a temperature drop as the web travels through the pocket 14, providing a greater AT between the web and cylinder surface, so providing better heat transfer and better use of the steam in the cylinder.

[0059] Each of the two foils 6, 7 in the plenum 1 has a specific function. The trailing foil 7 runs against the fabric 12, to push off the boundary layer B_{old}, which passes over the plenum 1. The warm dry air is fed into the void formed by the two foils at a positive pressure from the plenum 1, replenishes the removed boundary layer to form a new boundary layer B_{new} which immediately forms an attachment to the fabric 12, and is added to by a second flow of air along the leading foil 6, which forms a converging nip with the fabric 12 at the point where the fabric 12 and web 11 diverge to create a low pressure area. The air pressure from the plenum 1 combined with the negative pressure from the diverging surfaces and the converging foil 6 combine to give a significant flow of air through the fabric 12, creating a turbulent flow condition on the surface of the web 11.

[0060] The trailing foil 7 preferably runs against the fabric 12 in the same general direction as the direction of fabric movement. Alternatively, as shown in Figure 11, the trailing foil 7 may be directed contrary to the direction of fabric movement.

[0061] Plenums are situated near both the top and bottom pockets, in order to purge and replace the boundary layer in both locations. The top pockets (those pockets formed between two upper drying cylinders) draw in hot moist air from the hood (the canopy enclosing the drying apparatus), which soon becomes saturated. The bottom pockets (those between two lower cylinders) pick up cold air from the basement (the underside of the drying apparatus) and actively pump it into the hood. This also becomes saturated very quickly and cools the hood air, unless the plenum foils are used to counteract it.

[0062] A drying cylinder enclosure or hood is a very effective way of collecting the evaporated moisture and making it ready for extraction but, for the extraction to be effective, the hot moisture-laden air taken out has to be replaced by an equal amount of warm dry air and all this air comes through the plenums 1. Maintaining a balance between the volume of removed and replaced air prevents air being drawn from the basement (which would

lower the hood air temperature and thus its ability to carry moisture).

[0063] Furthermore, air drawn from the basement would normally take a short cut through the drying cylinder section to feed the exhaust extraction, without purging the pockets, thus causing a typical 'hump' in the moisture profile. This needs elimination prior to size press application or machine calendering. This problem is addressed by the present invention.

[0064] Balancing the warm air input via the plenums 1 ensures controlled and balanced air distribution throughout the hood, to improve web heat up, promote evaporation, optimise heat recovery and save on steam. Using this form of balanced system, there is no need for basement enclosure, as the hot air will not be inclined to move to the basement nor will the cold air have any inclination to move up into the drying cylinders.

[0065] A control system associated with the plenums 1 may be provided which enables the extraction volume to be controlled to suit the evaporation loads and humidity levels in the exhaust flow to optimise heat recovery, while allowing humid air to be fed through a plenum in the first section to inhibit evaporation. This helps achieve through-heating of the web during the heating phase. In turn, this optimises heat recovery, quality control, steam usage and heat recovery. Typically the system allows the exhaust to run at about 60% of the air in circulation.

[0066] The actual volume of air to the foils is controlled by an internal flow control mechanism associated with the plenum that allows the specific flow to be controlled across the length of the plenum to allow more or less air in the middle or the edges, according to needs. This mechanism is preset upon commissioning, but can be adjusted with suitable tools from the front side. Normally more air is required in the middle, as the edges of the web tend to dry slightly faster.

[0067] The foils flex under pressure to provide the ideal shape to skim off the boundary layer and cause the air to squeeze through the fabric and create the turbulent boundary layer, so effective in taking moisture from the web. The plenum is mounted 100 mm off the periphery of the cylinder to allow the free passage of wads of paper, when wrap ups and breaks occur.

[0068] A plenum can be simply installed in specific pockets where humidity levels are very high and with no other changes to an otherwise conventional drying apparatus. The effect of installing the plenum can reduce the relative humidity in the pocket by at least 50%.

[0069] The present invention is particularly useful on board drying apparatus which run relatively slowly and therefore have very large volumes of moisture to be removed but with very little speed to cause the pumping action.

Claims

1. Web drying apparatus having a permeable dryer fabric to hold the web being dried against the peripheries of a plurality of drying cylinders, the apparatus being provided with at least one plenum which extends laterally between adjacent drying cylinders, the plenum having an outlet directed towards the permeable fabric where the fabric leaves one cylinder and a foil which extends from the plenum to the permeable fabric at the downstream side of the outlet with respect to the direction of fabric movement to direct web drying medium leaving said outlet through said permeable fabric and against said web, the apparatus being **characterised in that** said plenum further comprises a second foil which extends from the plenum to the permeable fabric at the upstream side of the outlet with respect to the direction of fabric movement to redirect at least some of the boundary layer of air away from said fabric before said fabric passes said outlet.

2. Web drying apparatus as claimed in claim 1 wherein either or both of said foils are flexible so as to be deflectable so that a paper wad or the like can pass.

3. Web drying apparatus as claimed in claim 1 or claim 2 wherein said web drying medium is heated air.

4. Web drying apparatus as claimed in any of the preceding claims wherein either foil is removeable and replaceable from said plenum, preferably by sliding said foil laterally from a groove in the exterior surface of said plenum.

5. Web drying apparatus as claimed in any of the preceding claims wherein either foil is made from a laminate comprising epoxy resin and glass fibre.

6. Web drying apparatus as claimed in any of claims 1-4 wherein either foil is made from metal, preferably aluminium or spring steel.

7. Web drying apparatus as claimed in any of the preceding claims wherein either foil comprises a brush.

8. Web drying apparatus as claimed in any of the preceding claims wherein said second foil extends from said plenum to said fabric substantially in the direction of fabric movement.

9. Web drying apparatus as claimed in any of claims 1-7 wherein said second foil extends from said plenum to said fabric substantially contrary to the direction of fabric movement.

10. Web drying apparatus as claimed in any of the preceding claims wherein said second foil is pivotally attached to said plenum.

11. Web drying apparatus as claimed in any of the pre-

ceding claims wherein either foil is bent to a predetermined shape prior to attaching said foil to said plenum.

12. Web drying apparatus as claimed in any of the preceding claims wherein said plenum comprises a plurality of plenum sections attached together to give a plenum of the desired length, the plenum sections being formed from flat-pack sections which can be assembled on site.

13. Web drying apparatus as claimed in any of the preceding claims wherein said plenum includes a plurality of outlets arranged along the length of the plenum.

14. Web drying apparatus as claimed in any of the preceding claims wherein said plenum includes flow rate control means to enable the flow rate of drying medium through the or each outlet to vary along the length of the plenum.

15. Web drying apparatus as claimed in any of the preceding claims wherein said plenum has an end stop in the form of an extension provided with a curved wall against which either foil may be deflected to substantially prevent overbending of the foil.

16. Web drying apparatus as claimed in any of the preceding claims wherein said plenum is spaced by at least 100mm from the adjacent drying cylinder.

17. Web drying apparatus as claimed in any of the preceding claims wherein said plenum is generally triangular in cross-section.

18. Web drying apparatus as claimed in any of the preceding claims wherein the free edge of either foil is curved back away from said fabric.

19. A plenum for use in web drying apparatus as claimed in any of claims 1-18, the plenum having
an outlet which, in use, is directed towards the permeable fabric where the fabric leaves one cylinder
a foil which, in use, extends from the plenum to the permeable fabric at the downstream side of the outlet with respect to the direction of fabric movement to direct web drying medium leaving said outlet through said permeable fabric and against said web, and
a second foil which, in use, extends from the plenum to the permeable fabric at the upstream side of the outlet with respect to the direction of fabric movement to redirect at least some of the boundary layer of air away from said fabric before said fabric passes said outlet.

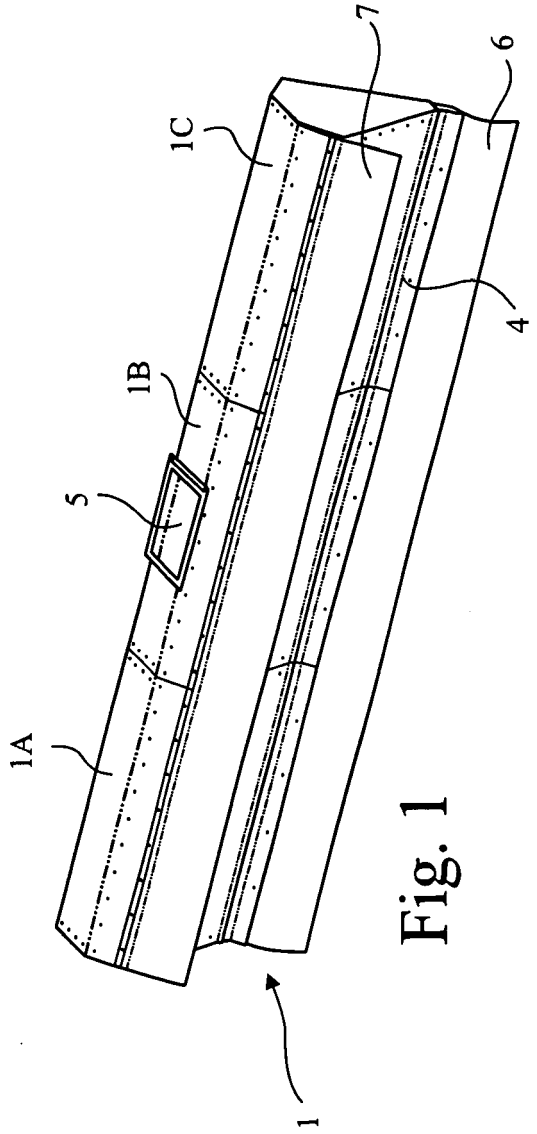

Fig. 1

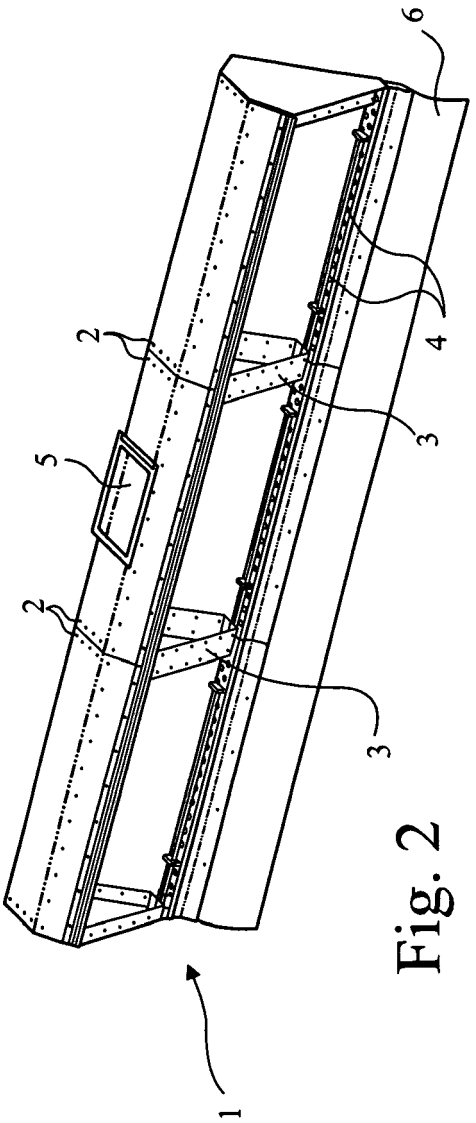

Fig. 2

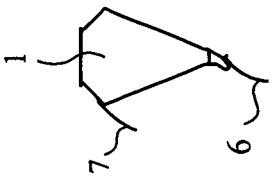

Fig. 8

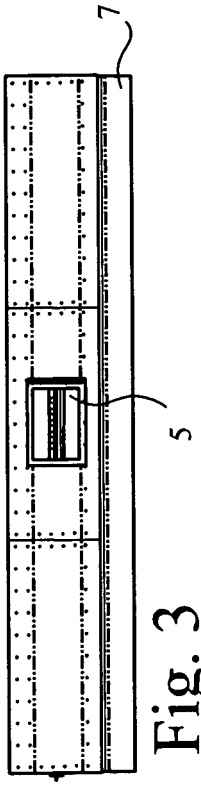

Fig. 3

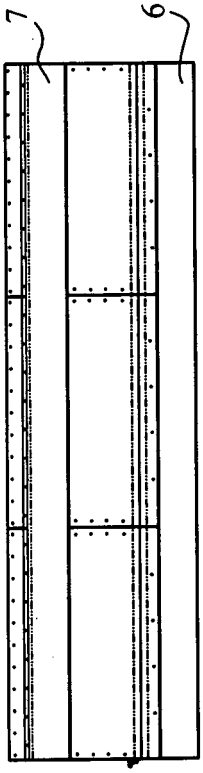

Fig. 4

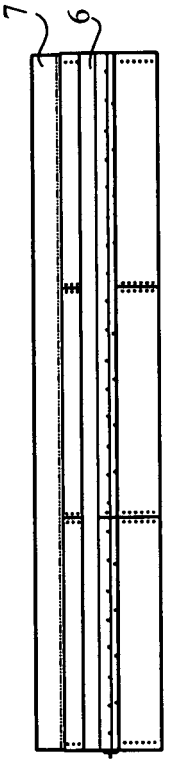

Fig. 5

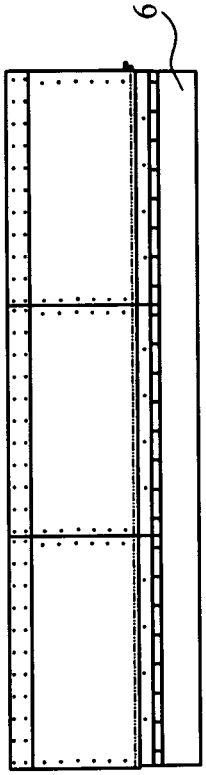

Fig. 6

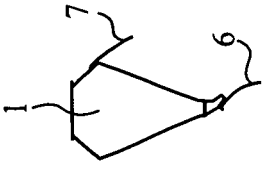

Fig. 7

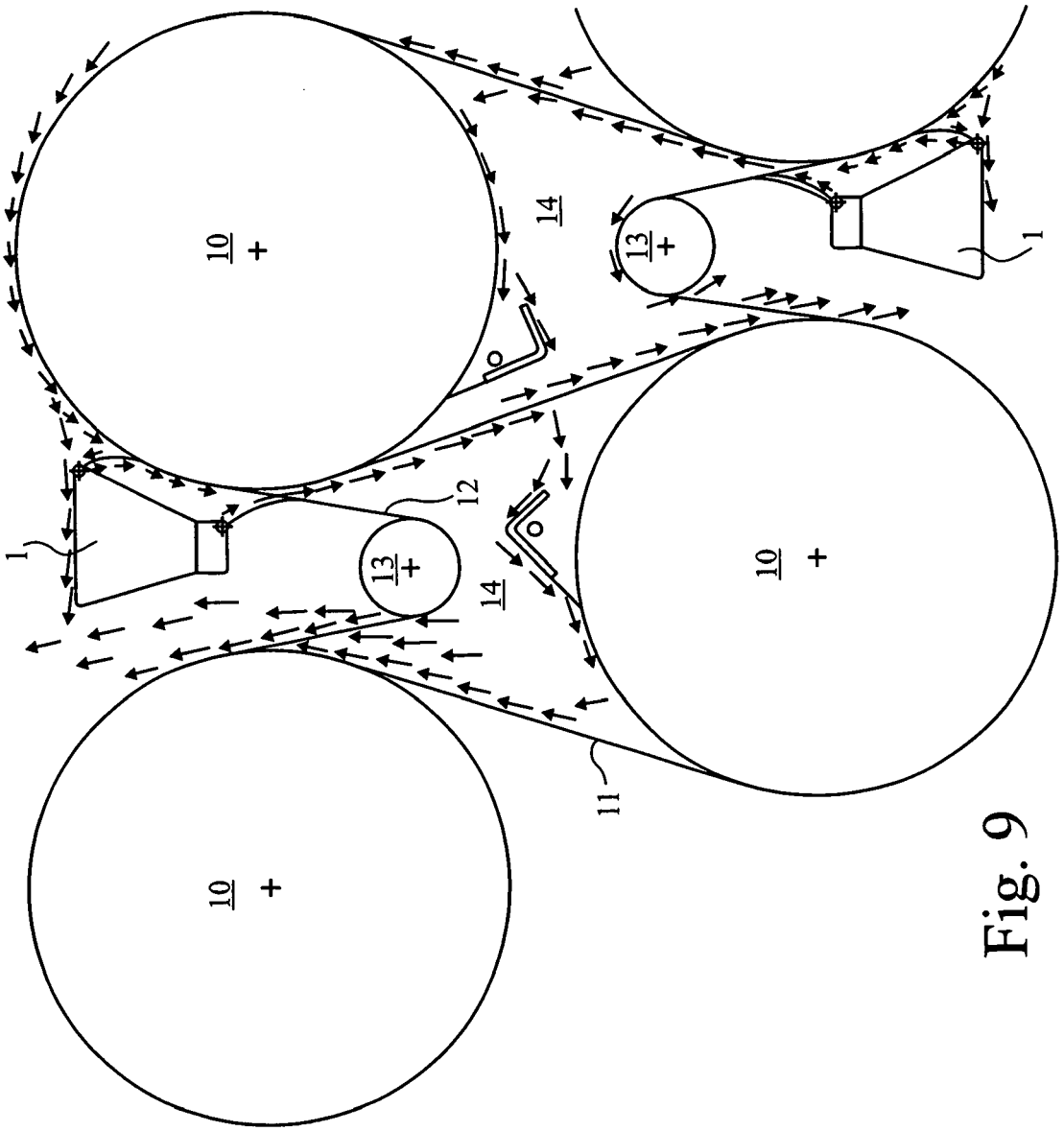

Fig. 9

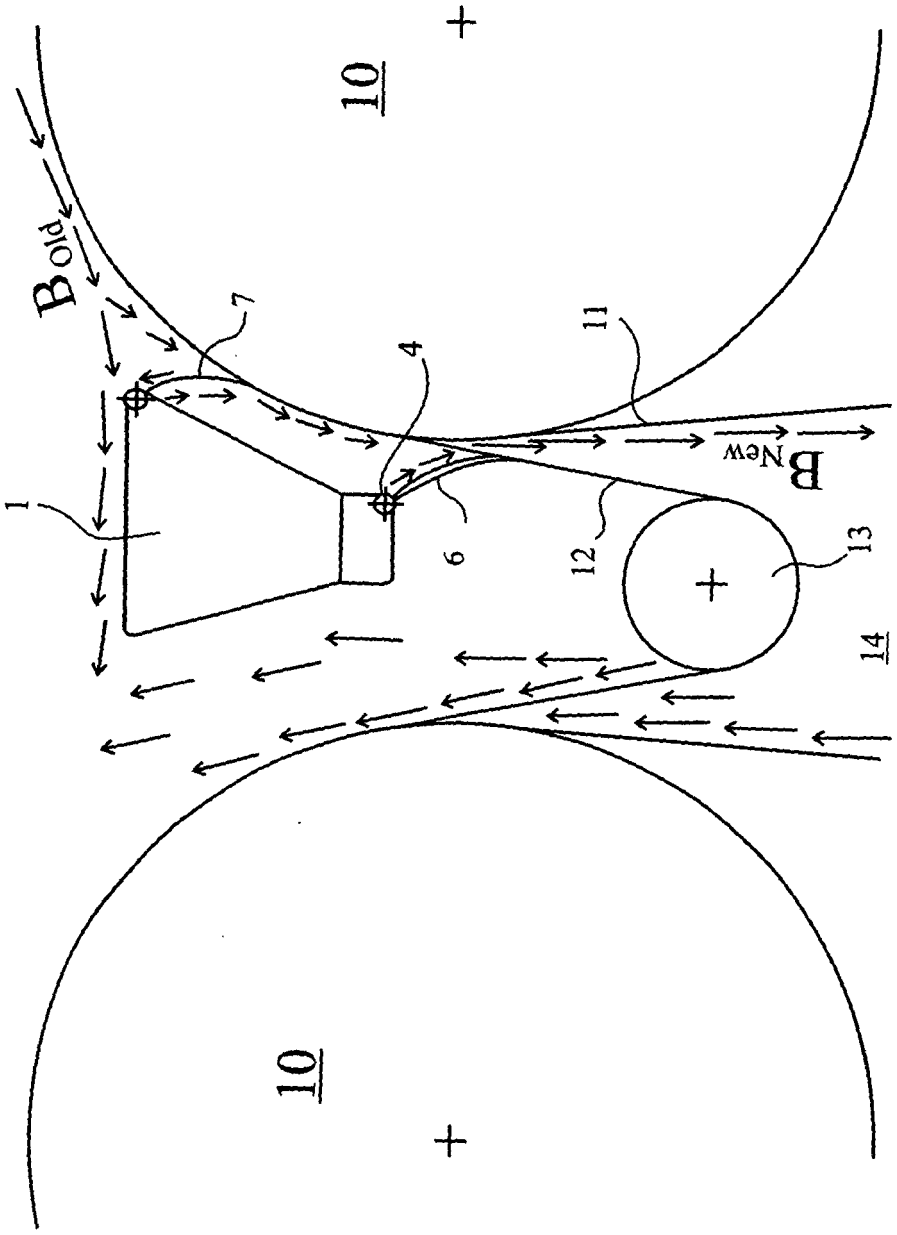

Fig. 10

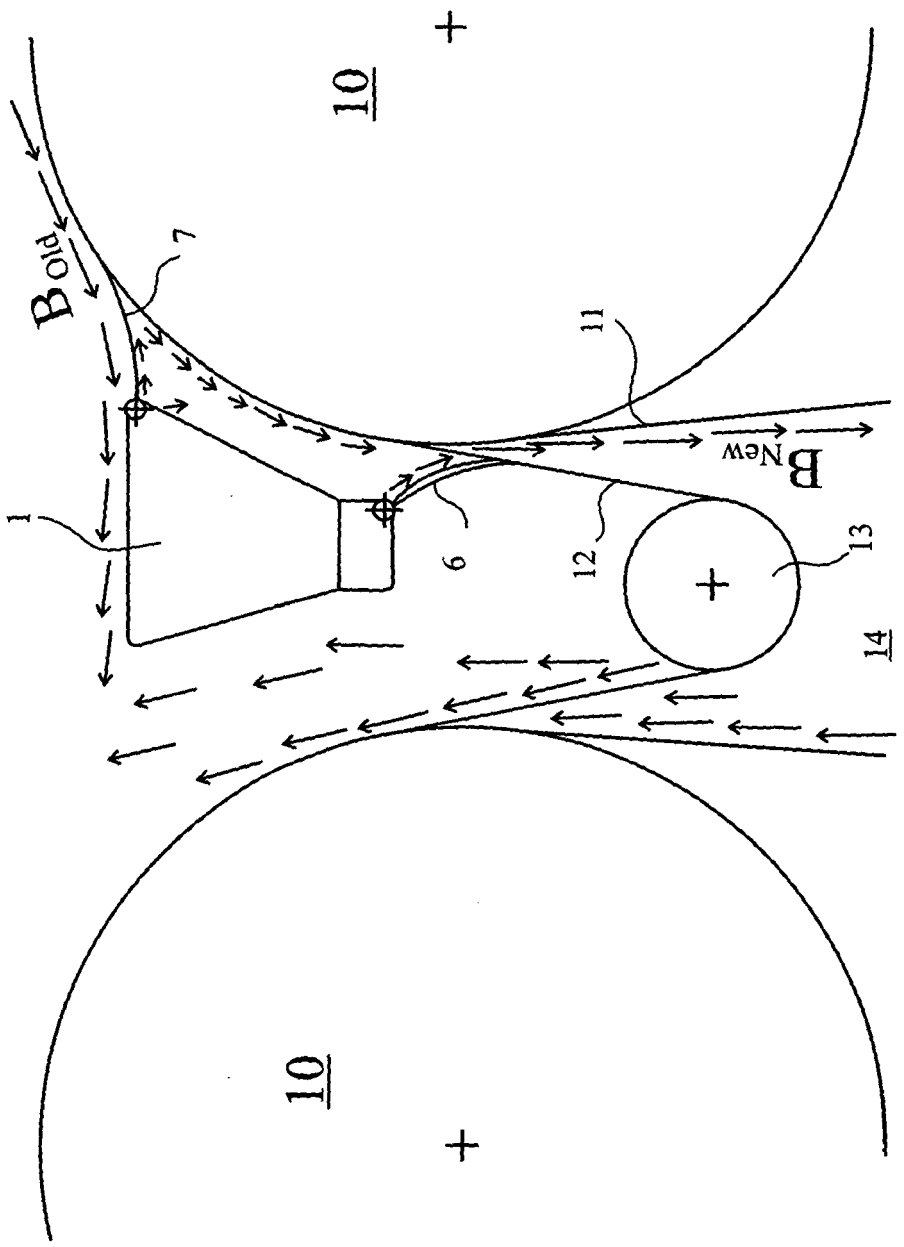

Fig. 11

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Application Number
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D21F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	9 October 2006	Gast, Dietrich

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